



# ***DARPA*Tech**

## ***2002 Symposium***

*Transforming*  
***Fantasy***

# **Michael J. Goldblatt**

Director

[mgoldblatt@darpa.mil](mailto:mgoldblatt@darpa.mil)

<http://www.darpa.mil>

**Defense  
Sciences Office**



**Where the Magic Begins!**



# Office Thrusts

**Biological Sciences**

***Biological  
Warfare Defense***

***Biology***

***Bio-Materials***

**Materials & Devices**

**Functional  
Materials**

**Smart Materials  
and Structures**

**Structural  
Materials and  
Components**

**Power and Water**

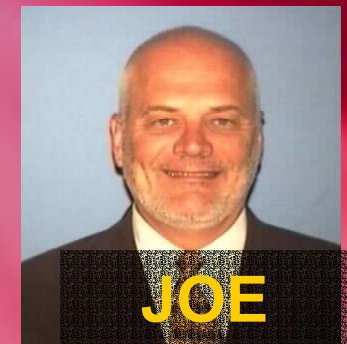
**Applied and  
Computational  
Mathematics**

**Mathematics**





# The Argonauts



# DSO Alumnus in Space



# Future Areas of Emphasis

- ▶ Brain Machine Interface
- ▶ Logistic Technologies
- ▶ Enhancing Human Performance
- ▶ Exploiting Complex Systems





# DSO Presenters

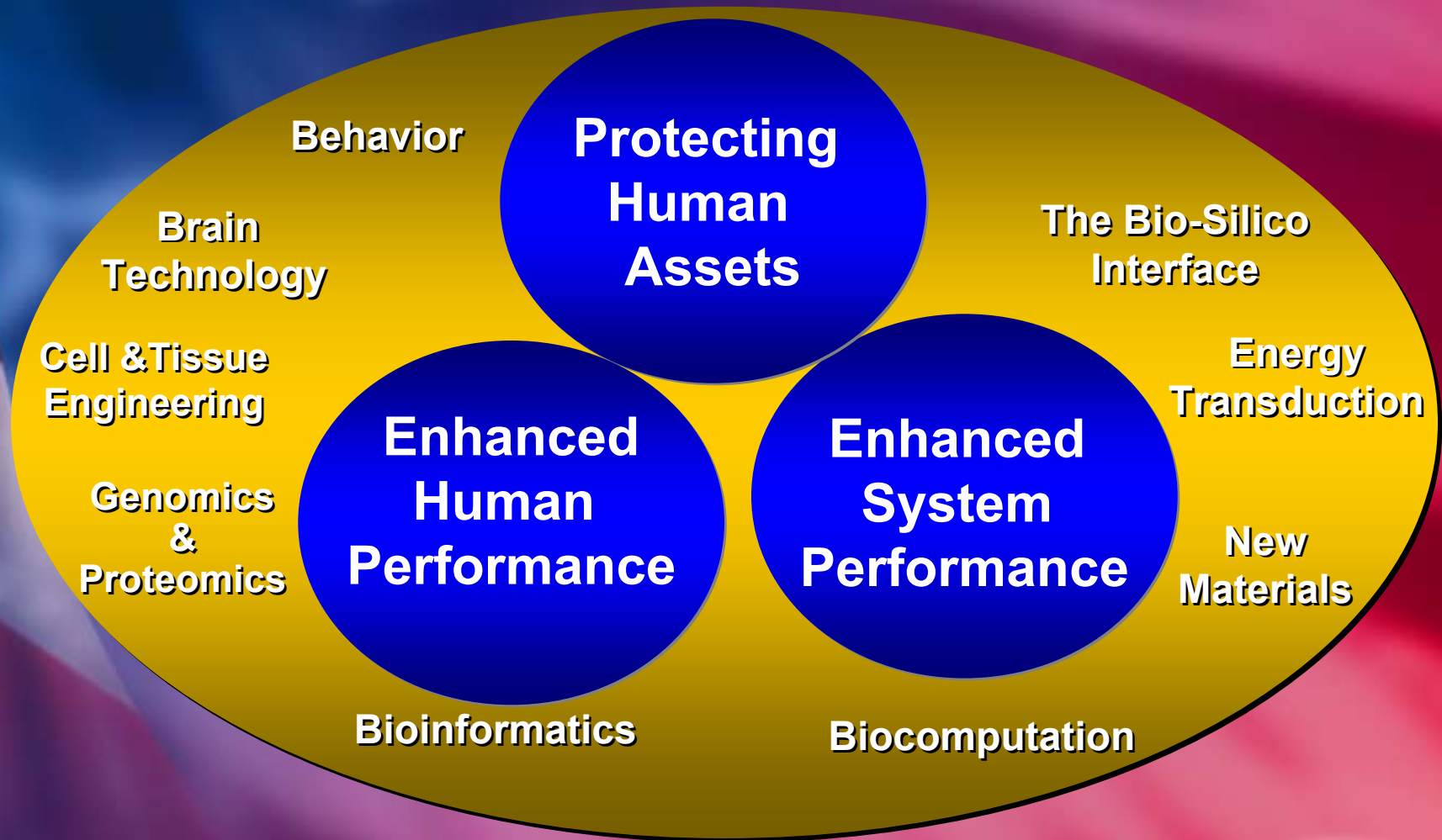
- ▶ Steve Wax – Enhancing System Performance
- ▶ Joe Bielitzki – Enhancing Human Performance
- ▶ Doug Cochran – Exploiting Complex Systems
- ▶ Valerie Browning – Material Science
- ▶ Eric Eisenstadt – Brain Machine Interface





# Biology...

## DARPA's Future Historical Strength



# Biology

## Protecting Human Assets

Minutes to Hours

Minutes to Hours

Hours to Days

Hours to Days

**Bio  
Event**

Sensors

Protection  
Collective/  
Building

Consequence  
Management

- Advanced Diagnostics
- Medical Countermeasures
- Decontamination



Genome Sequencing

*Fantasy*

# Biology: Enhanced Systems Performance

**Mechanical systems as autonomous  
and adaptable as living things**



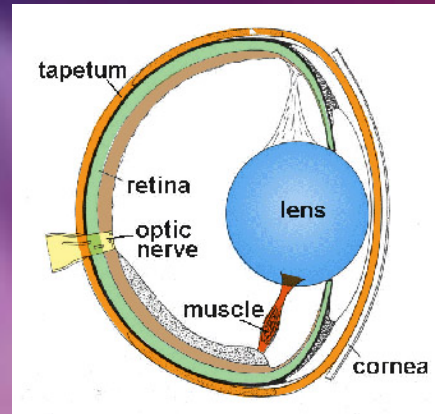


# Enhanced System Performance

**Develop materials, devices and systems based on understanding and inspiration of biological systems**

## Bio-optics Synthetic Systems

### Morphing Structures



### DNA Computing



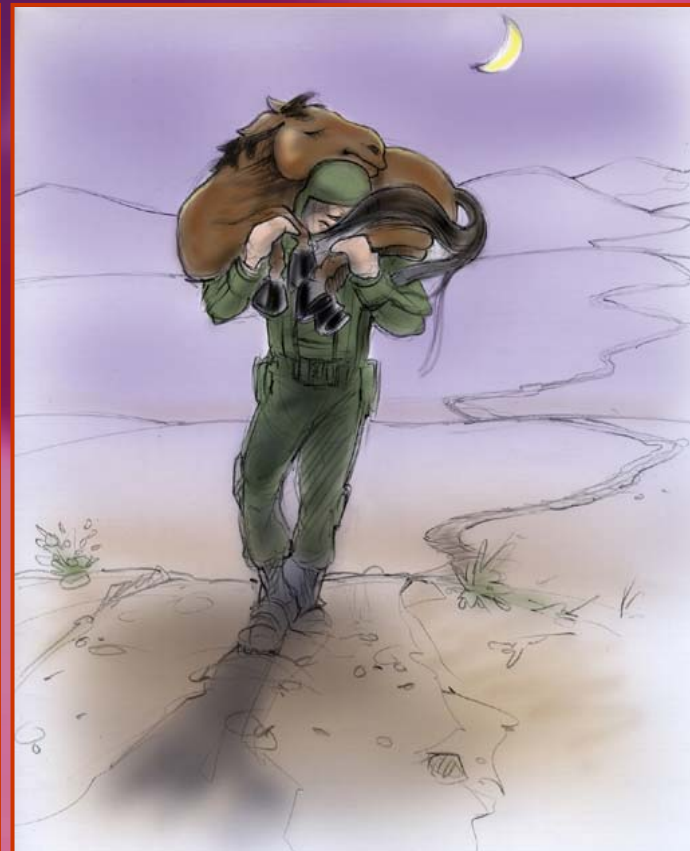
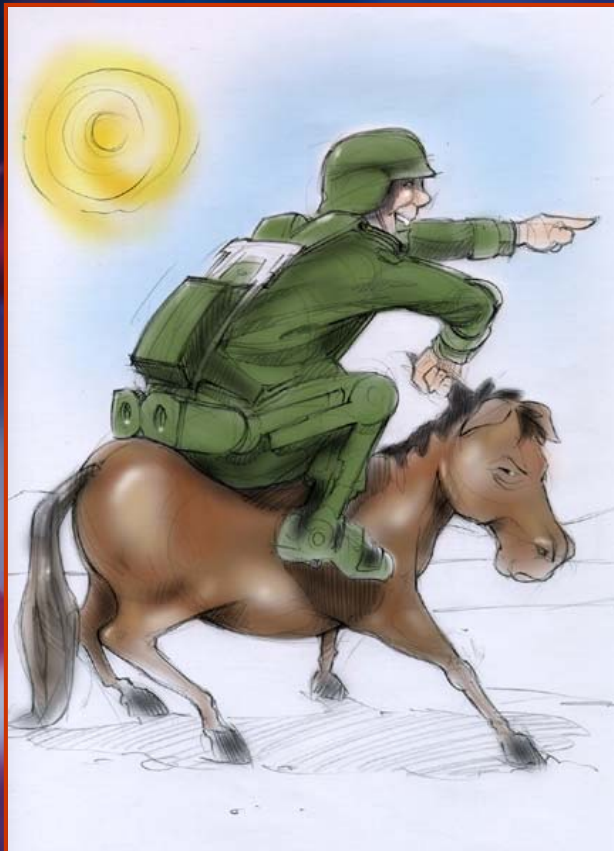
### Bioinspiration for mobility



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Fantasy

# Enhancing Human Performance

## Exoskeleton





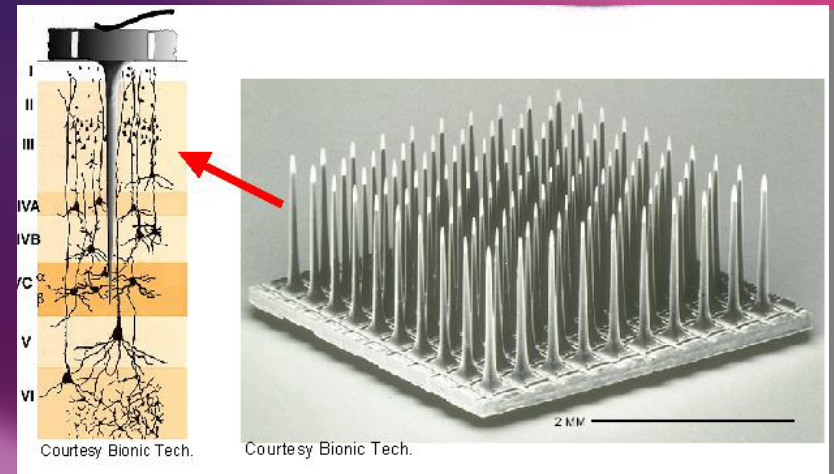
***Michael***



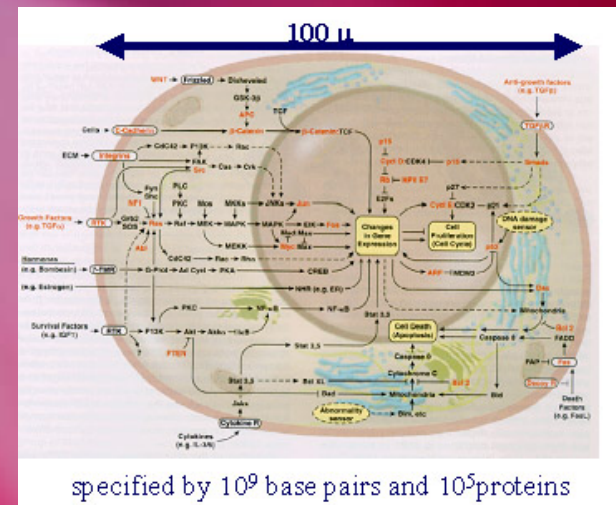


# BioVision: Tools at the Interface

- ▶ Neuroprocessing and neurocontrol via high density implantable MEMS devices



- ▶ Measuring and modeling the dynamic behavior of biological regulatory networks in living cells

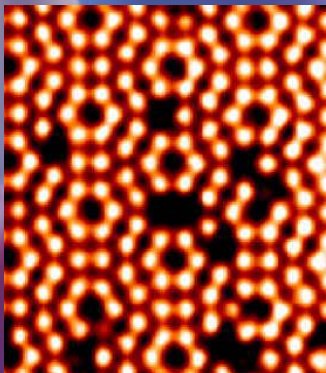


# MOSAIC

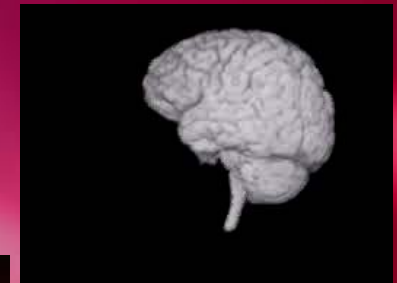
## Molecular Observation, Spectroscopy and Imaging using Cantilevers

Develop new instrumentation to do real-time 3D static or dynamic imaging of molecules and nanostructures with atomic level resolution.

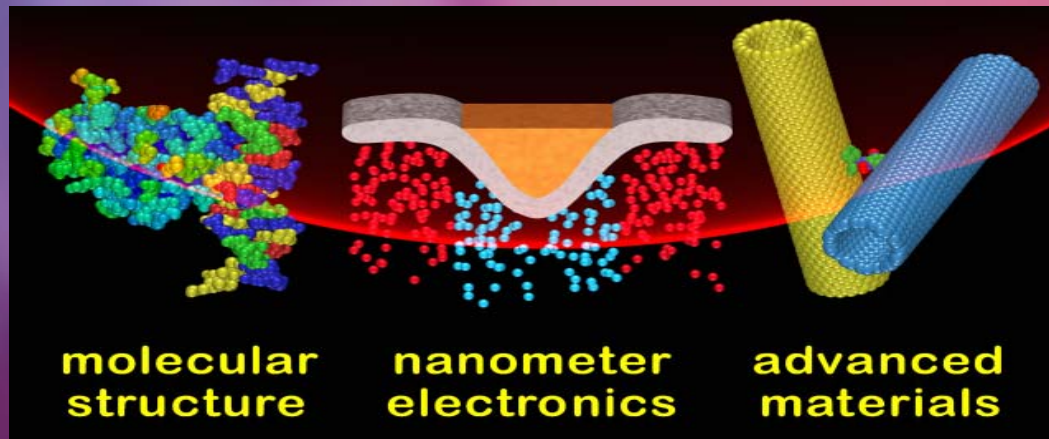
### Scanning Probe Microscopy



### Magnetic Resonance Imaging



### Magnetic Resonance Force Microscopy

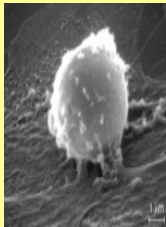


# Bio-Magnetic Interfacing Concepts

Integrate nano-scale magnetics with biology as a powerful novel transduction mechanism for portable robust real-time bio-detection and cellular communication

## Ferrofluids

Bio-detection:



Magnetic Carriers  
(therapeutics/imaging):



## Magnetic Sensors

High Sensitivity Designs:

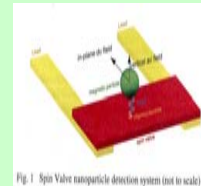
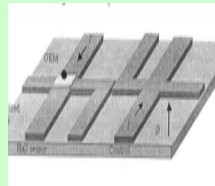
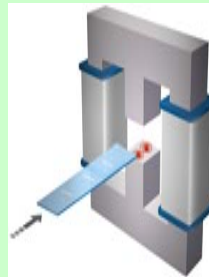


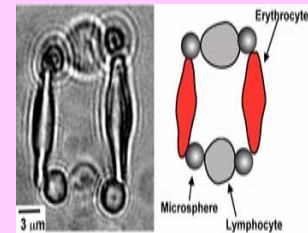
Fig. 1. Spin Valve nanoparticle detection system (not to scale)

Bio-Magnetic scanner:

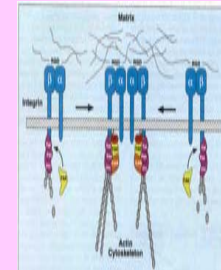


## Magnetic Tweezers

molecular manipulation:



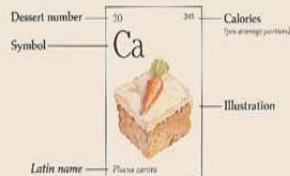
cellular signaling:














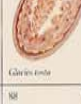






# PERIODIC TABLE OF THE DESSERTS

## KEY TO CHART



# Imagine .....

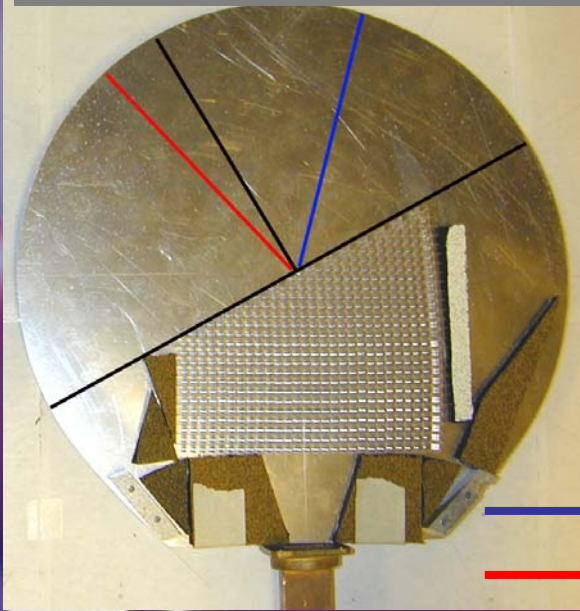
NOTES: Values have been calculated for an average portion of each dessert shown in a typical recipe. Actual values may vary with serving size, recipe and garnish.  
\*Desserts 27-31 and 89-93\*\* belong to the inner transition series. Entries for 32 and 88 have not been depicted on this chart.

1 H  <i>Sorbetto fragante</i>		KEY TO CHART																2 He  <i>Cappuccino mello</i>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
3 Li  <i>Gelato cilantro</i>		4 Be  <i>Crouton caribbeus</i>																		5 B  <i>Placsa feta</i>		6 C  <i>Crouton caribbeus</i>		7 N  <i>Biscione sordido</i>		8 O  <i>Crouton cilantro</i>		9 F  <i>Crouton thalassus</i>		10 Ne  <i>Sorbetto lacini</i>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
11 Na  <i>Gelato immensum</i>		12 Mg  <i>Placsa onidionis</i>																		13 Al  <i>Crouton meliorum glorie</i>		14 Si  <i>Gelato fragrans</i>		15 P  <i>Amulus varius</i>		16 S  <i>Sorbetto granivus</i>		17 Cl  <i>Biscione folium</i>		18 Ar  <i>Cappuccino amantissimus</i>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
19 K  <i>Sorbetto arvensis</i>		20 Ca  <i>Placsa rosula</i>		21 Sc  <i>Pomona frugis lacte</i>		22 Ti  <i>Biscione hyssopus</i>		23 V  <i>Gelato onidionis</i>		24 Cr  <i>Crouton corvuli</i>		25 Mn  <i>Crouton citri</i>		26 Fe  <i>Cappuccino feta</i>		27 Co  <i>Placsa polytypus</i>		28 Ni  <i>Gelato nactis</i>		29 Cu  <i>Gelato condimentis</i>		30 Zn  <i>Gelato talassus</i>		31 Ga  <i>Gelato terrisus</i>		32 Ge  <i>Cappuccino picea</i>		33 As  <i>Sorbetto idios</i>		34 Se  <i>Pomona poposum</i>		35 Br  <i>Placsa viridis</i>		36 Kr  <i>Sorbetto cornu</i>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
37 Rb  <i>Pasta mollioratus</i>		38 Sr  <i>Placsa frugis</i>		39 Y  <i>Gelato mundus</i>		40 Zr  <i>Sorbetto corvuli</i>		41 Nb  <i>Placsa naturalis</i>		42 Mo  <i>Gelato regalis</i>		43 Tc  <i>Amulus streptus</i>		44 Ru  <i>Cappuccino iudicium</i>		45 Rh  <i>Crouton ruberolus</i>		46 Pd  <i>Gelato villis</i>		47 Ag  <i>Placsa divus</i>		48 Cd  <i>Pomona mala</i>		49 In  <i>Gelato cultus</i>		50 Sn  <i>Cappuccino vicidulus</i>		51 Sb  <i>Gelato malis</i>		52 Te  <i>Delicatum atroxus</i>		53 I  <i>Gelato interius</i>		54 Xe  <i>Cappuccino maculatus</i>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
55 Cs  <i>Placsa vitrus</i>		56 Ba  <i>Gelato fides</i>		57 La  <i>Biscione rhododendrylon</i>		58 Hf  <i>Gelato ambrosianus</i>		59 Ta  <i>Gelato concorsus</i>		60 W  <i>Placsa heliopsis</i>		61 Re  <i>Placsa pomosum</i>		62 Os  <i>Cappuccino optimus</i>		63 Ir  <i>Gelato idios</i>		64 Pt  <i>Delicatum optulensia</i>		65 Au  <i>Crouton kokibolus</i>		66 Hg  <i>Placsa incertus</i>		67 Tl  <i>Sorbetto viridulus</i>		68 Pb  <i>Cappuccino elephantus</i>		69 Bi  <i>Amulus ferrugineus</i>		70 Po  <i>Gelato iudicis</i>		71 At  <i>Sorbetto mala</i>		72 Rn  <i>Placsa metaphisica</i>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
73 Fr  <i>Pomona incertus</i>		74 Ra  <i>Cappuccino amplexus</i>		75 Ac**  <i>Sorbetto arvensis</i>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			

# Meta-Materials

Design and build new materials with properties not available in nature

*Example: Negative index of refraction,  $n$ , ( $m, \epsilon < 0$ ) observed in microwave transmission through left-handed meta-material!*



Teflon

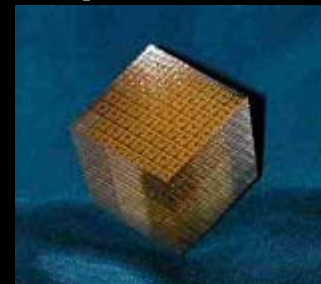
Left-handed meta-material

## Novel Processing Capabilities



**June 2001**

copper on printed circuit board



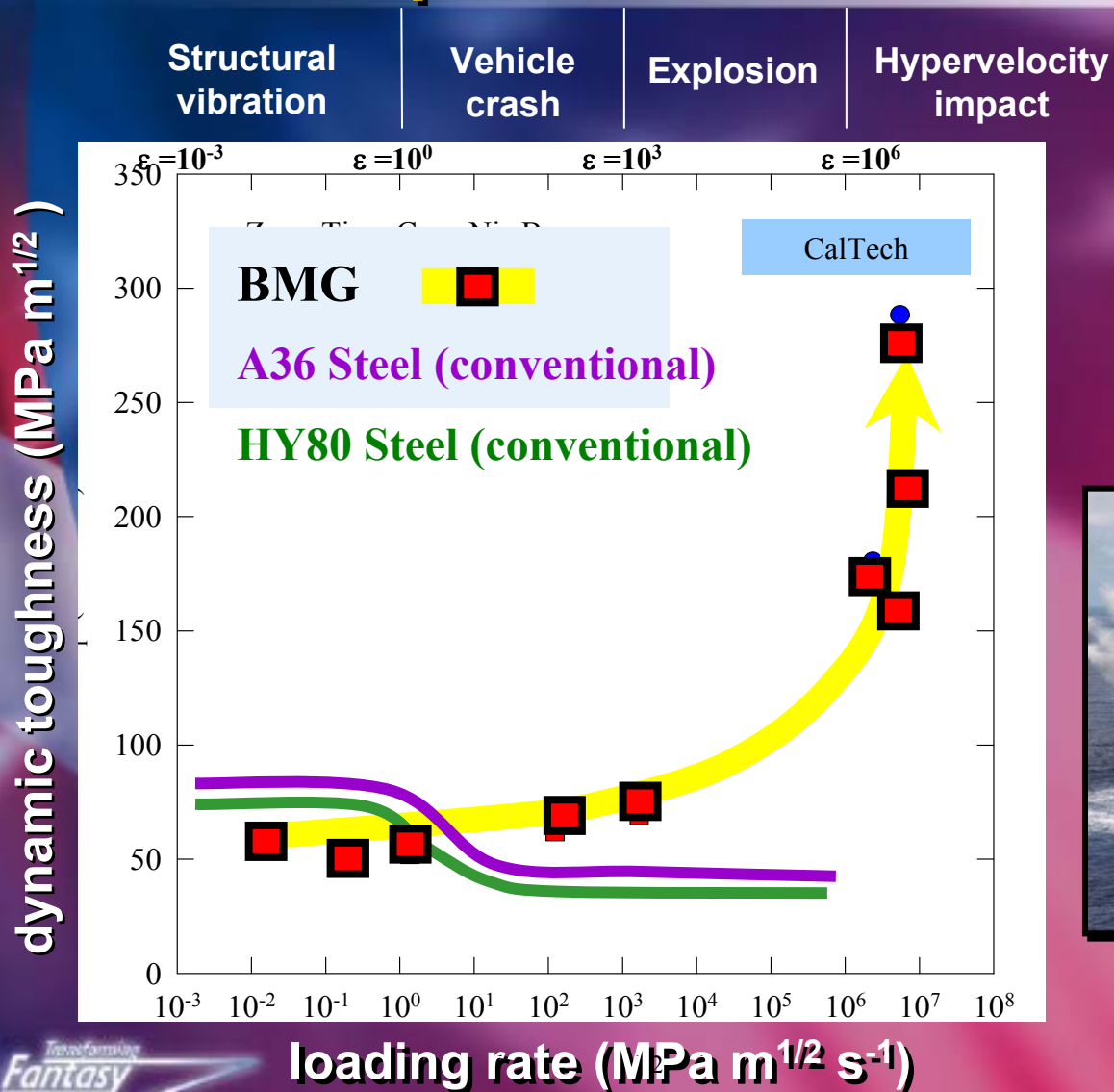
**January 2002**

machinable, robust, composite





# New-to-the-World Structural Materials: Unexpected Strain Rate Response in SAM

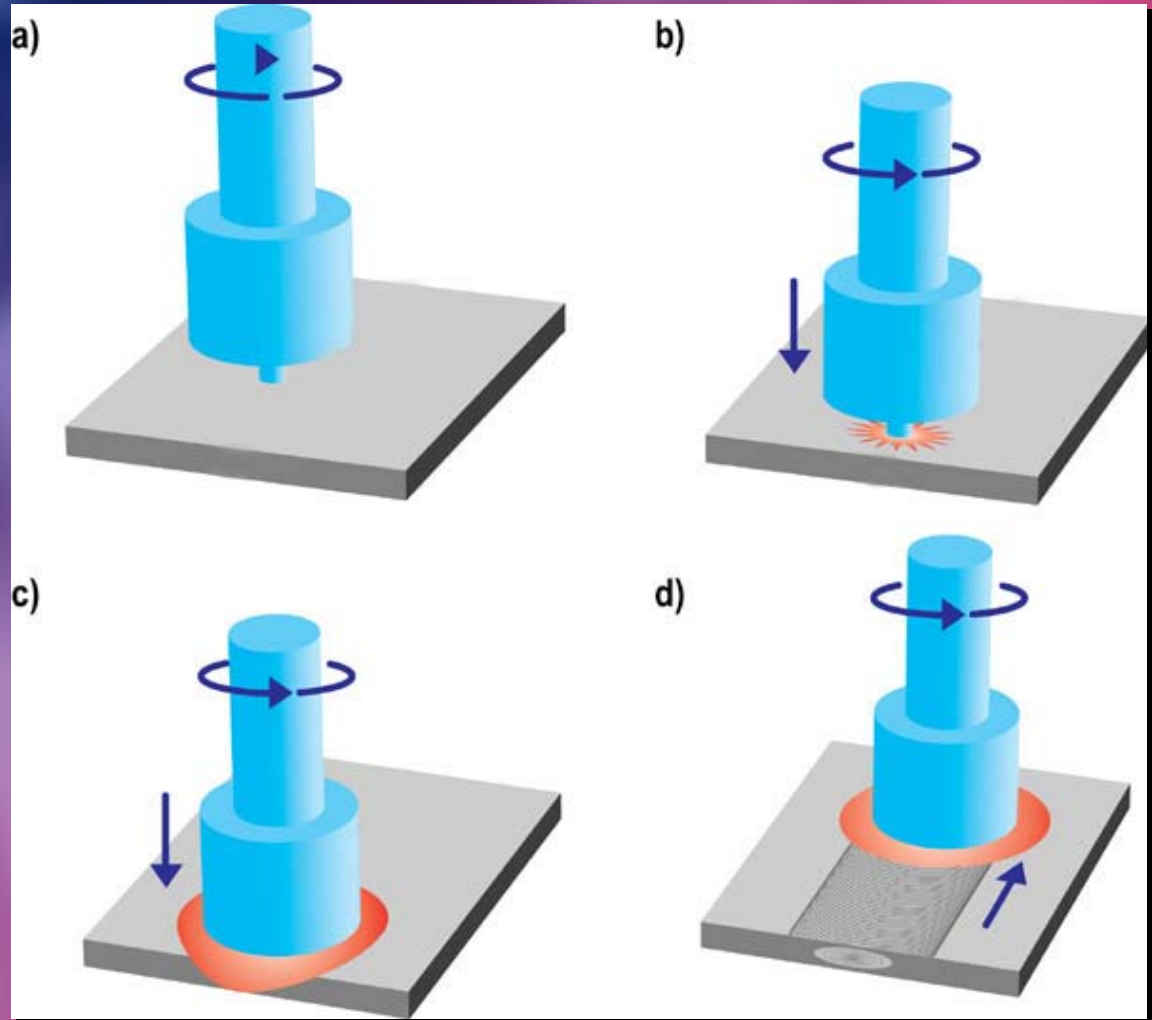




# Friction Stir Processing



FSP Tool



# Imagine.....



*Transforming*  
**Fantasy**

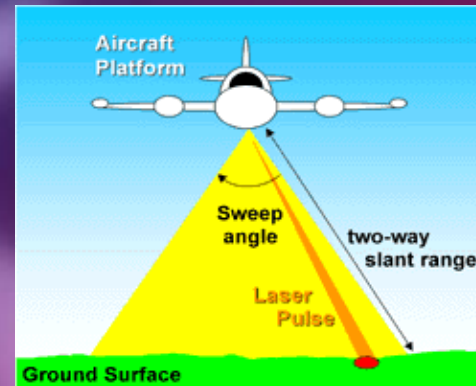






# Femtosecond LAsers for Material Evaporation

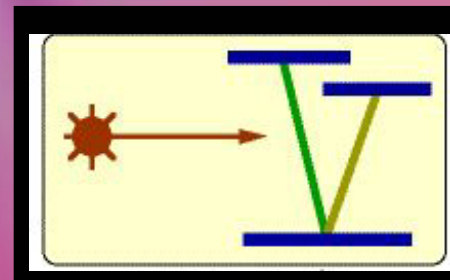
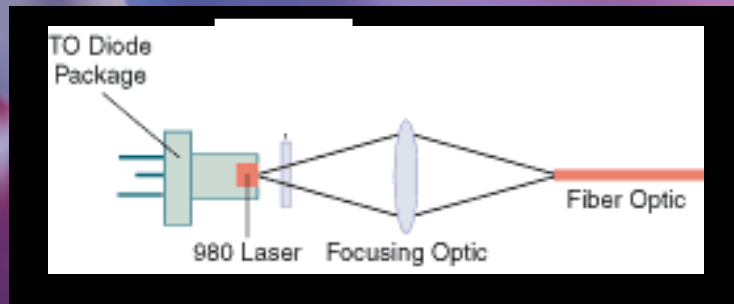
LIDAR



Micromachining

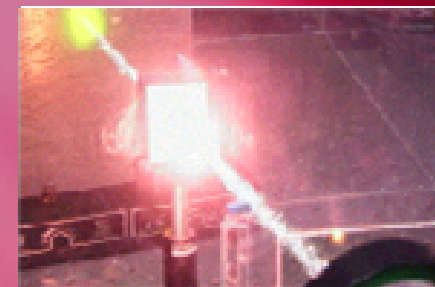


Optical communications

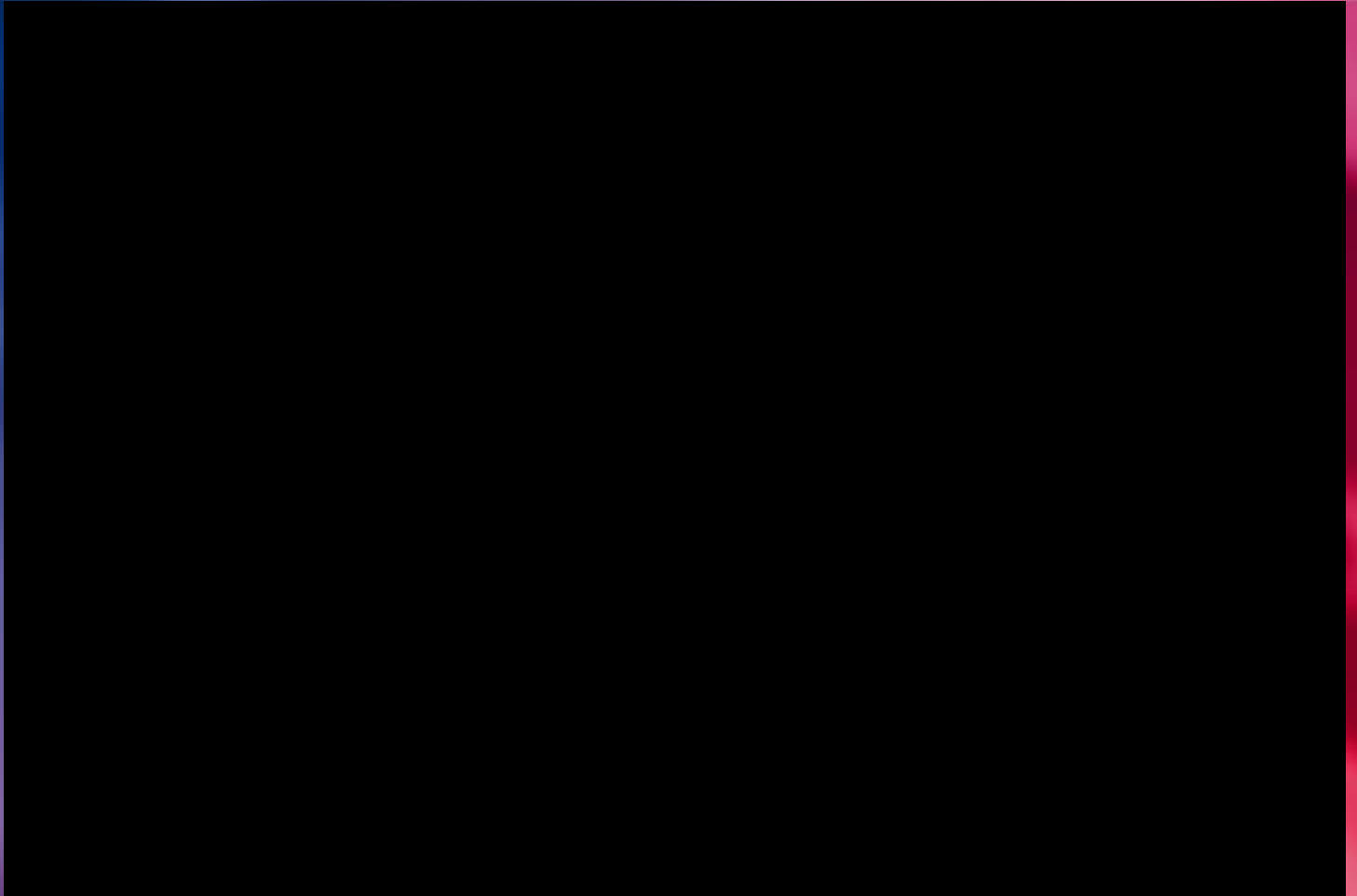


Spectroscopy

Directed energy

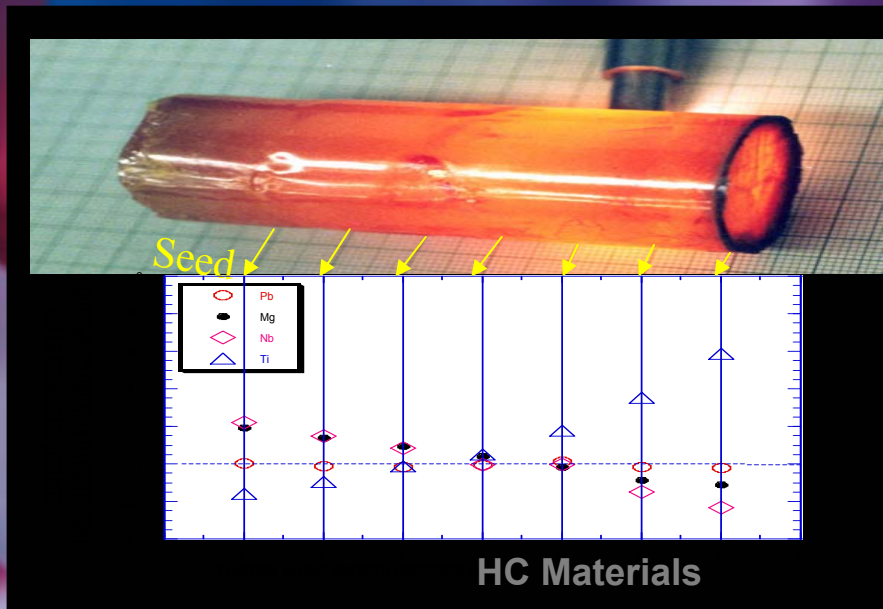


# Mesososcopic Integrated Conformal Electronics

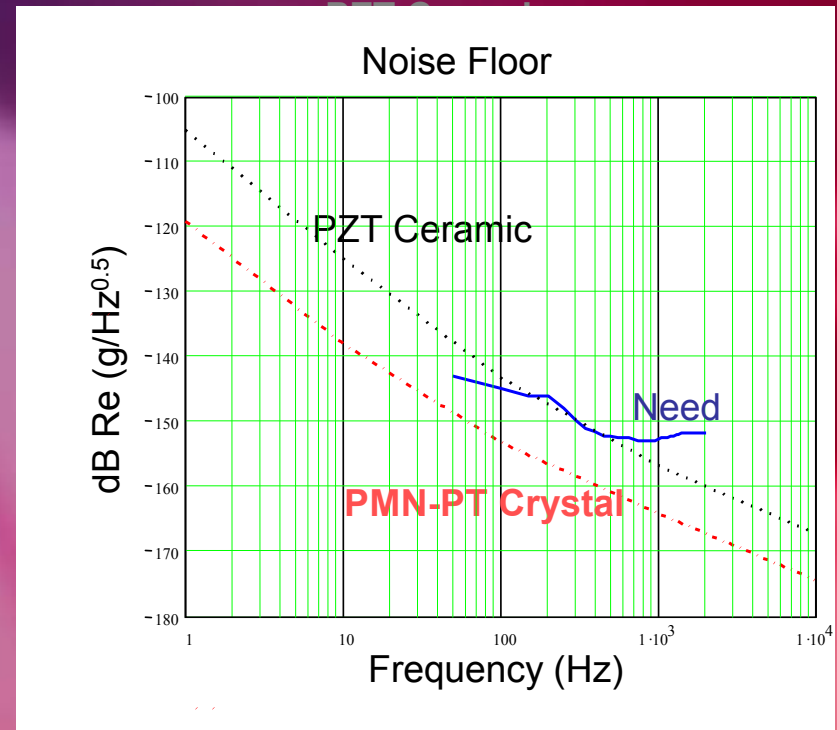


# Piezoelectric Single Crystals for Electromechanical Transduction

Material Available for  
Device Prototyping



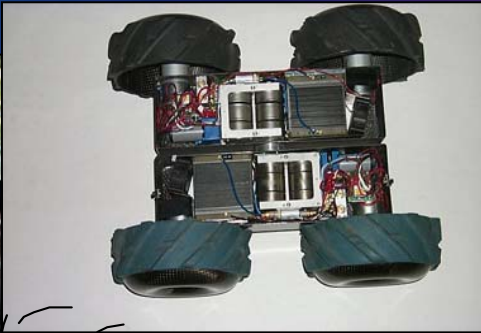
Accelerometer 10-15dB Less Noise





# Palm Power

## Robots



## System Integration

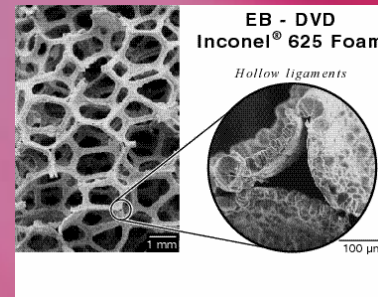
- Fabrication
- Cascading Systems



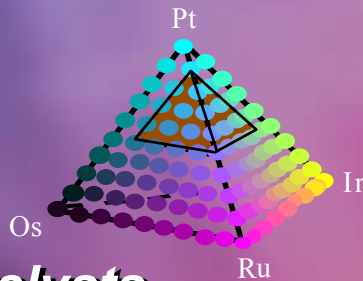
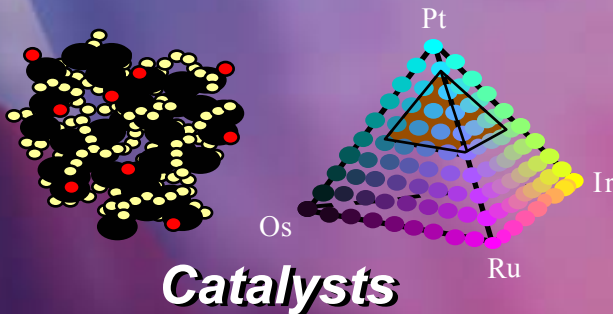
*High T*

*Low T*

## Thermal Management



## Materials Development



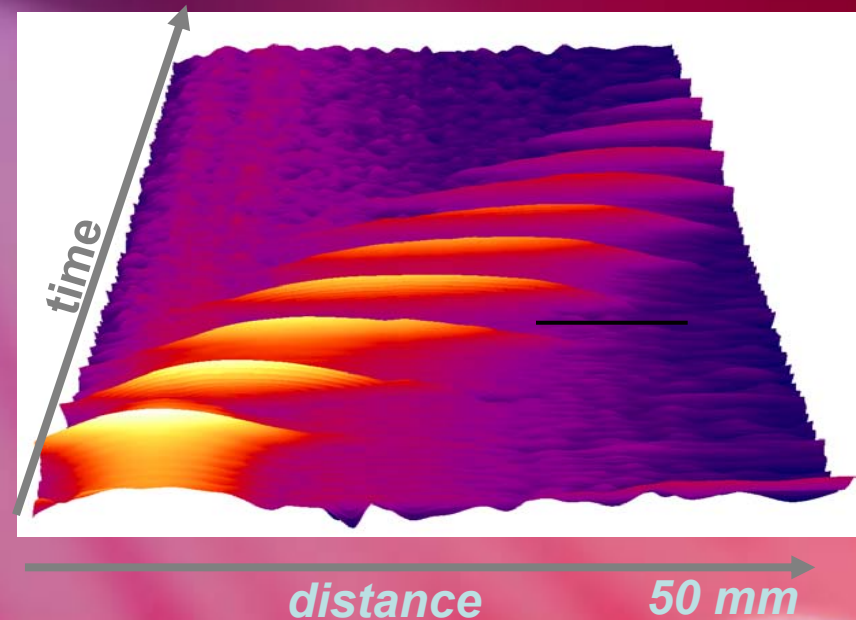
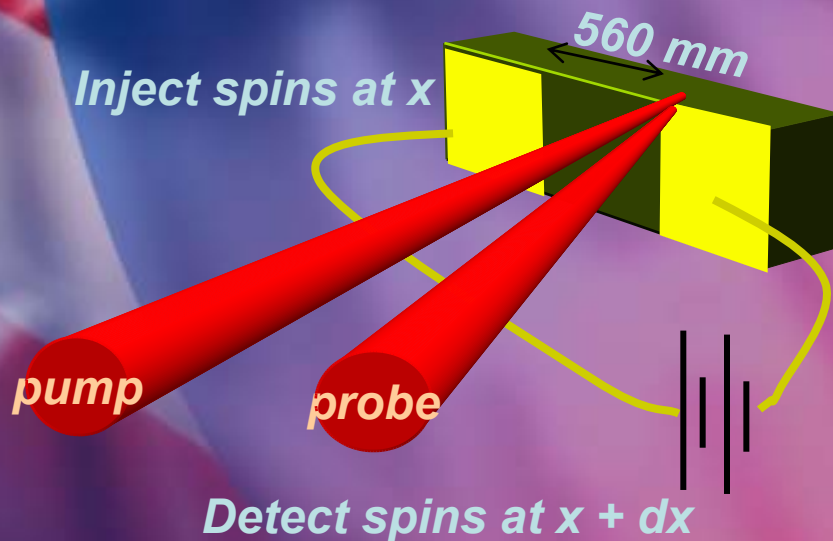
**Catalysts**

***Thermal Conductors...and Insulators***



# Injection and Motion of Coherent Spins in Semiconductors

- ▶ Spin coherence persists for 100's of nanoseconds over 100's of microns
- ▶ Largely insensitive to temperature

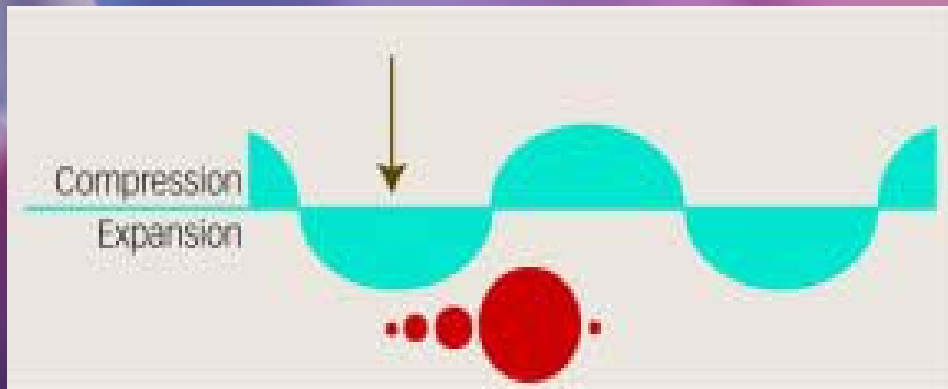
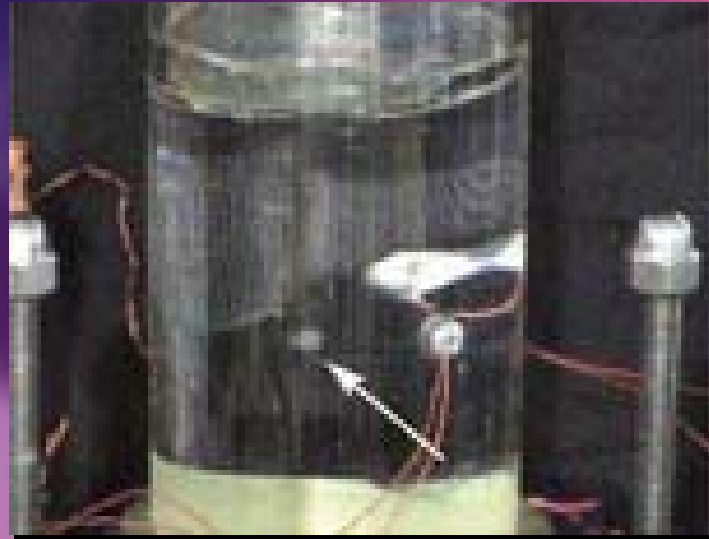






# Sonoluminescence

**Bubble Magic:** In a flask of acetone bombarded by sound waves, a cloud of bubbles (arrow) swells to the size of a pea before collapsing



**The Big Squash :** A neutron pulse (arrow) combines with a sound signal (blue) in a flask of acetone to generate the conditions for a bubble (brown) to form, grow, and then implode with great force

**Steve**







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